

## RESEARCH REPORT

# Backpack palsy and other brachial plexus neuropathies in the military population

Sanne M. Dorhout Mees<sup>1</sup>  | Nina L. van Faals<sup>2</sup> | Nens van Alfen<sup>3</sup>

<sup>1</sup>Joint Military Hospital, Utrecht, The Netherlands

<sup>2</sup>University Medical Center Utrecht, Utrecht, The Netherlands

<sup>3</sup>Department of Neurology, Donders Institute for Brain, Cognition and Behaviour, Radboud University Medical Center, Nijmegen, The Netherlands

## Correspondence

Sanne M. Dorhout Mees, Joint Military Hospital, Lundlaan 1, Utrecht 3584 EZ, The Netherlands.

Email: s.m.dorhoutmees@umcutrecht.nl

## Abstract

Brachial plexus neuropathy is often seen in the military population, especially due to pressure (backpack palsy, BPP) or idiopathic (neuralgic amyotrophy, NA). We aimed to gain insight in the disease characteristics of soldiers with brachial plexus neuropathies in the Dutch military population and to compare disease characteristics between patients with BPP and NA. In this retrospective chart review study we aimed to include all patients with brachial plexus neuropathy, who presented in the Joint Military Hospital between 1 January, 2011 and 31 December, 2016. We calculated the incidence of NA and BPP and Chi-square tests or Student *t* tests were performed for differences in patient characteristics between NA and BPP. We included 127 patients, 63 with BPP, 45 with NA, 10 with traumatic brachial plexus neuropathy, and 9 with other plexopathy. The incidence of brachial plexus neuropathy was 50/100 000 person years overall, 25/100 000 person years for BPP, and 18/100 000 person years for NA. Patients in the BPP group differed from the NA with regard to pain (BPP 41% vs NA 93%,  $P = .000$ ), atrophy (13% BPP vs 29% NA,  $P = .049$ ), and sensory symptoms (83% BPP vs 44% NA,  $P = .000$ ). In the BPP group 90% had incomplete recovery and in the NA group 78%. Our study showed a high incidence of BPP and NA in the military population and suggests recovery is not so benevolent as previously thought. Future research is necessary to improve insight and outcome of military patients with brachial plexus neuropathies.

## KEYWORDS

brachial plexopathy, military, neuralgic amyotrophy

## 1 | INTRODUCTION

Brachial plexus neuropathy is a common disorder seen in the military population.<sup>1,2</sup> In our experience, this disorder is more prevalent in soldiers than in the general population. Brachial plexus neuropathy can have different etiologies: traumatic, for example, sharp injuries or traction on the plexus as can be seen with motorbike injuries, idiopathic, known as neuralgic amyotrophy (NA), or due to direct pressure.<sup>3</sup>

Pressure neuropathy of the brachial plexus, also known as backpack palsy (BPP) is typical for the military population, although some case reports of BPP in civilians are found in the literature.<sup>4,5</sup>

Neuralgic amyotrophy is a clinically defined syndrome characterized by acute onset, severe pain in the shoulder and/or upper arm(s), with subsequent multifocal peripheral nervous system symptoms that can be bilateral but are always asymmetric. Criteria for this disorder have been described in previous publications.<sup>6,7</sup>

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2020 The Authors. *Journal of the Peripheral Nervous System* published by Wiley Periodicals, Inc. on behalf of Peripheral Nerve Society.

Nowadays BPP usually occurs during training programs, in which soldiers can carry up to 60 kg of load. The condition was first described in 1969 in Vietnam soldiers.<sup>8</sup> The brachial plexus is injured by the weight of the backpack due to direct compression or stretch of the nerve tissue leading to demyelination, with or without axonal injury. Patients with BPP usually have symptoms during or after marching with high loads.<sup>9</sup> The first symptoms are often paresthesia's, and when the patient removes his backpack, he experiences loss of muscle strength in the affected limb. In contrast to NA, pain is uncommon, or due to muscle exercise of affected muscles in a later stadium. At clinical examination, sensory disturbances have often disappeared and muscle weakness, with or without a winged scapula, is the dominant feature. Because of the neurological deficit, soldiers are not or partially employable, or even unfit for military duty. This can lead to high burden for the patients and high costs for the military organization.

While there currently is a reasonable amount of knowledge in the literature about NA in the general population, which seems to be a common form of plexopathy with an estimated incidence of 1 per 1000 in The Netherlands,<sup>6</sup> information on BPP is limited and consists of small studies. The purpose of this study was to gain insight in the incidence, severity and recovery of soldiers with brachial plexus neuropathies in the Dutch military population and to compare disease characteristics between patients with BPP and patients with NA.

## 2 | MATERIALS AND METHODS

In this retrospective chart review study we aimed to include all patients with brachial plexus neuropathy, who presented in the Dutch Joint Military Hospital (JMH) between 1 January, 2011 and 31 December, 2016. In The Netherlands we have a professional army and no compulsory military service. All military personnel has to be referred to the Joint Military Hospital, and patients who develop ailments while abroad on a mission or training camp are repatriated to this hospital. Patients were identified via the Dutch mandatory diagnostic codes for plexopathies; "plexopathy and other peripheral nerve disease" and "mononeuritis otherwise." We searched all electronic patient files to check the diagnosis of a brachial plexus neuropathy. Patients were categorized in four categories. We used the following definitions based on the clinical profile:

- BPP: backpack palsy, a neurological deficit consistent with brachial plexopathy within 24 hours of activity with direct shoulder compression, such as carrying a backpack.
- NA: neuralgic amyotrophy, a neurological deficit consistent with a brachial plexopathy without a provoking activity or other cause, usually with, but rarely without pain in the shoulder region at onset and a multifocal distribution of weakness, commonly involving the serratus anterior muscle.
- Traumatic plexopathy: a neurological deficit consistent with brachial plexopathy directly after relevant trauma.
- Other: another plexopathy, not consistent with or categorizable as one of the prior categories.

We used the diagnosis as established by the treating neurologist, however if the researcher (NLF) was in doubt about the categorization this was discussed with another researcher (S.M.D.M.) to reach consensus. Patients were excluded if the final diagnosis was not a plexopathy.

We retrieved patient characteristics, symptoms, and results of electromyography (EMG), magnetic resonance imaging (MRI), and Lyme disease serology from the medical records. We also collected information on follow-up when available. Informed consent was not obtained, because this is not obligatory in The Netherlands for retrospective chart review studies. We did obtain permission for conducting the study from the military research committee and military medical ethical board.

We calculated the incidence of NA and BPP presenting in the JMH using the numbers of all active professional military personnel in The Netherlands during the study period. Statistical analyses were performed for differences in characteristics of the two main categories NA and BPP. We calculated *P*-values by means of the Chi-square test for qualitative variables or Student *t* tests for continuous variables. *P*-values of  $\leq .05$  were considered statistically significant.

## 3 | RESULTS

We included 127 patients, of whom 63 were diagnosed with BPP and 45 with NA. Ten patients were diagnosed with traumatic brachial plexus neuropathy and nine with other plexus neuropathies. This last group consisted of patients with iatrogenic brachial plexus neuropathy due to shoulder surgery ( $n = 5$ ), postradiation neuropathy ( $n = 1$ ), or patients who were not classifiable in one of the other groups ( $n = 3$ ). In all groups the majority of patients was male (67-98%). Within the BPP group patients were mainly in service of the Royal Navy (69%, mainly trainees or marines of the Marine Corps) followed by the Royal Army (infantry, 24%). In the NA group patients were more distributed among the four armed forces (16%-38%, Table 1). For comparison, the distribution of military personnel in the forces are 18% Royal Navy, 39% Royal Army, 16% Royal Airforce, 15% Royal Marechaussee (Military Police), 10% non-armed forces. The average percentage of woman is 10% (ranges from 15% in the Royal Marechaussee to 7% in the Royal Army).

During the study period of 6 years, there was an average of 42 000 military service personnel per year. Based on this numbers the incidence of brachial plexus neuropathy diagnosed in the outpatient neurology clinic of the CMH was 127/42 000 per 6 years = 50/100 000 person years overall, and 63/42 000 per 6 years = 25/100 000 person years for BPP and 45/42 000 per 6 years = 18/100 000 person years for NA, respectively.

Analyses were performed to compare characteristics between the BPP and the NA group. Patients in the BPP group were considerably younger than patients in the NA group, with a mean age of 23 years (standard deviation [SD] 7), and 40 years (SD 11), respectively;  $P \leq .001$ . Patients were predominantly male (98% in BPP group and 96% in NA group). In the BPP group, 53 of the 63 patients (84%) had marched with a backpack in the 24 hours previous to developing symptoms; other causes for the plexopathy reported were carrying other heavy loads on the shoulder or sleeping on hard ground (Table 1).

**TABLE 1** Patient characteristics

	Backpack palsy (N = 63)	Neuralgic amyotrophy (N = 45)	P	Traumatic (N = 10)	Other (N = 9)
Mean age (SD)	23 (7)	40 (11)	.000	35 ( $\pm$ 15)	44 (12)
Male (N)	62 (98%)	43 (96%)	.359	9 (90%)	6 (67%)
Military service (N)*					
Royal Navy	42 (67%)	7 (16%)		5 (50%)	0 (0%)
Royal Army	15 (24%)	17 (38%)		3 (30%)	3 (33%)
Royal Air Force	3 (5%)	13 (29%)		2 (20%)	3 (33%)
Royal Marechaussee	1 (2%)	7 (16%)		0 (0%)	3 (33%)
Smoking (N)	17 (27%)	10 (22%)	.712	1 (10%)	1 (11%)
Marching <24 h (N)	53 (84%)	0 (0%)	.000	0 (0%)	0 (0%)
Backpack (N)	53 (84%)	0 (0%)	.000	0 (0%)	0 (0%)
Mean weight (kg, SD; N = 21)	40 (8)	-		-	-

\*2 patients unknown.

**TABLE 2** Clinical characteristics and follow-up

	Backpack palsy (N = 63)	Neuralgic amyotrophy (N = 45)	P	Traumatic (N = 10)	Other (N = 9)
Bilateral symptoms	8 (13%)	2 (4%)	.170	0 (0%)	0 (0%)
Pain	26 (41%)	42 (93%)	.000	9 (90%)	5 (56%)
Proximal motor deficit	57 (90%)	40 (89%)	.542	10 (100%)	5 (56%)
Distal motor deficit	20 (32%)	20 (44%)	.135	3 (30%)	4 (44%)
Winged scapula	41 (65%)	20 (44%)	.252	3 (30%)	2 (22%)
Atrophy	8 (13%)	13 (29%)	.049	2 (20%)	2 (22%)
Sensory symptoms	52 (83%)	20 (44%)	.000	7 (70%)	9 (100%)
Median follow-up (weeks, interquartile range)	9.0 (4-22)	22.0 (8-35)	.378	68 (34-127)	26 (5-122)
Complete recovery	4 (8%)	2 (6%)		0 (0%)	0 (0%)
Partial recovery	44 (90%)	25 (78%)		0 (0%)	3 (50%)
No recovery	1 (2%)	5 (16%)		0 (0%)	3 (50%)
Recurrence	3 (5%)	2 (4%)	.993	0 (0%)	0 (0%)

In all groups motor weakness was the most common symptom. Proximal muscle weakness was more common in the BPP group (91%) as well as in the NA group (89%) than distal muscle weakness: 32% for BPP and 44% for NA, Table 2). There were no differences in occurrence of winged scapula (65% in the BPP group, 44% in the NA group). Patients in the BPP group differed from the NA with regard to pain (BPP 41% vs NA 93%,  $P = .000$ ), atrophy (13% BPP vs 29% NA,  $P = .049$ ), and sensory symptoms (83% BPP vs 44% NA,  $P = .000$ , Table 2).

Diagnostic procedures were performed in a limited number of patients and more often in the NA group. In the NA group 38% of patients underwent MRI scanning of the brachial plexus, 67% EMG, and 20% laboratory testing (mostly anti-Borrelia burgdorferi antibodies); in the BPP group this was 14%, 37%, and 0%, respectively (Table 3).

In the BPP group follow-up data were known of 51 patients (81%) and in the NA group of 34 patients (76%). There was large variation in the follow-up time with a median follow-up of 9 weeks (interquartile range 4 and 22 weeks) in the BPP group, and 22 weeks in

the NA group (interquartile range 8 and 35 weeks), respectively. In the BPP group four patients (8%) had complete recovery within the follow-up time, in the NA group two patients (6%). Most of the patients had incomplete recovery (meaning still symptoms or neurological deficits, 90% in the BPP group and 78% in the NA group). A prior episode of BPP was reported in 5% of patients in the BPP group and in 4% of the NA group.

## 4 | DISCUSSION

Our study showed an overall incidence for plexus brachialis neuropathies in the military population of 50/100 000 person years. Due to the retrospective nature of this study there will have been selection bias and we believe the true incidence will be even higher.

For BPP only, we calculated an incidence of 25/100 000 person years for BPP. This number is in line with incidence numbers described in the literature of 15.7 to 53.7 per 100 000 person

**TABLE 3** Diagnostic procedures

	Backpack palsy (N = 63)	Neuralgic amyotrophy (N = 45)	P	Traumatic (N = 10)	Other (N = 9)
MRI plexus brachialis (N)	9 (14%)	17 (38%)	.005	5 (50%)	8 (89%)
No abnormalities (N)	8 (13%)	10 (22%)		3 (30%)	5 (56%)
Abnormalities of Plexus brachialis (N)	1 (2%)	0 (0%)		1 (10%)	1 (11%)
Other abnormalities (N)	0 (0%)	7 (16%)		1 (10%)	2 (22%)
EMG (N)	23 (37%)	30 (67%)	.002	7 (70%)	6 (67%)
Sensory abnormalities (N)	5 (8%)	7 (16%)		1 (10%)	0 (0%)
Motor abnormalities (N)	1 (2%)	3 (7%)		1 (10%)	1 (11%)
Needle abnormalities (N)	15 (24%)	14 (31%)		5 (50%)	4 (44%)
Laboratory studies (N)	0 (0%)	8 (18%)	.000	0 (100%)	1 (10%)

Abbreviations: EMG, electromyography; MRI, magnetic resonance imaging.

years.<sup>1,2</sup> As 80% of the patients with BPP was <25 years, and we calculated incidence over the whole military population, the incidence for soldiers <25 years will be much higher. BPP is potentially preventable and leads to loss of employability of soldiers.

For NA we calculated an incidence of 18/10 000 person years. This is considerably higher than 1-3/100 000 person years that is historically found in the literature, but lower than recent prospective research showed after training of general practitioners in the general population (up to 1/1000 person years).<sup>6</sup> As military personnel and military doctors are not trained to recognize NA, we think our incidence of NA is still an underestimation and might be even higher than in the general population. As we know that mechanical impact on the shoulder is a risk factor for developing NA in the short term,<sup>10</sup> we theorize that subclinical nerve tissue injuries occurring in the brachial plexus due to years of carrying weight on the shoulders, could result in an increased risk of developing NA at a higher age.

Notable is that 41% of the BPP patients reported pain, whereas BPP is considered a painless condition. In our experience, the pain in BPP patients is much less severe as in NA patients, and mostly due to mechanical issues (e.g., winged scapula) or over-exertion of paretic muscles.

In our study recovery of symptoms in BPP was not very good, in only 8% of patients with BPP the symptoms completely recovered (meaning no symptoms or neurological deficit at follow-up visit) after a mean follow-up of 20 weeks. There is very limited literature about recovery after BPP; one study included 55 patients of whom 80% recovered within a median follow-up of 3 months.<sup>11</sup> Unfortunately, we do not have exact information about functional recovery, or if patients went back to active duty. Our results have to be interpreted with caution, as the follow-up time differed between the patients groups, and recovery was purely based on the patients history and physical examination during follow-up visits. Also, follow-up visits were not routinely scheduled but initiated by the treating neurologist. Nevertheless, our results suggest that BPP is not as harmless as currently thought, and we think that BPP leads to considerably burden for soldiers and cost for the army.

Strong points of our study are that patients were included over a long period of 6 years' time, leading to a large cohort of 127 patients.

Other European studies included 55 and 38 patients,<sup>1,4</sup> one other large Korean study included 122 patients.<sup>2</sup> To our knowledge this is the first study that included all types of brachial plexus neuropathy in military personnel and not only BPP. This enabled us to look for differences in disease characteristics between BPP and the much better known NA.

The study also has limitations. Data were collected retrospectively with a result of being incomplete, mostly with regard to diagnostic investigations and follow-up. Unfortunately, due to the retrospective nature of our study, there was no fixed protocol for nerve conduction and EMG studies, and imaging of the plexus was not routinely performed. Due to the study design, we suspect selection bias has occurred because not all patients were referred to the CMH. The diagnosed might have been missed by the military general practitioners, patients with mild symptoms might have not been referred at all, or patients could have been sent to another near-by hospital. Also, when the neurologist wrongly coded the diagnosis in the electronic patient file we will have missed the patient. We therefore suspect the real incidence of brachial plexus neuropathies to be higher than we found in our study. We could have underestimated recovery rates because patient with mild symptoms were not referred or lost to follow-up early. Some results are less reliable due to incomplete data like pain levels or weight of backpacks. We had no healthy control group and cannot report on risk factors for developing a brachial plexus neuropathy.

In conclusion, our study showed a high incidence of BPP and NA in the military population and suggests recovery is not so benevolent as previously thought. BPP is potentially preventable and leads to loss of employability of soldiers, and gaining more insight in this condition can help to inform, prevent, or treat future patients. Future research should focus on functional recovery, costs of drop-outs of soldiers, identifying risk factors, prognosis and recurrence numbers after brachial plexus neuropathy, and on possible prevention and therapeutic programs.

#### CONFLICT OF INTEREST

The authors state that they have no conflict of interests.

**ORCID**

Sanne M. Dorhout Mees  <https://orcid.org/0000-0002-4401-8021>

**REFERENCES**

1. Mäkelä JP, Ramstad R, Mattila V, Pihlajamäki H. Brachial plexus lesions after backpack carriage in young adults. *Clin Orthop Relat Res*. 2006;452:205-209.
2. Kim KE, Kim EJ. Incidence and risk factors for backpack palsy in young Korean soldiers. *J R Army Med Corps*. 2016;162:35-38.
3. Ferrante MA. Brachial plexopathies: classification, causes, and consequences. *Muscle Nerve*. 2004;30:547-568.
4. Rothner AD, Wilbourn A, Mercer RD. Rucksack palsy. *Pediatrics*. 1975;56:822-824.
5. Rose K, Davies A, Pitt M, Ratnasinghe D'Argenzio L. Backpack palsy: a rare complication of backpack use in children and young adults—a case report. *Eur J Paediatr Neurol*. 2016;20:750-753.
6. van Alfen N, van Eijk JJ, Ennik T, et al. Incidence of neuralgic amyotrophy (parsonage turner syndrome) in a primary care setting—a prospective cohort study. *PLoS One*. 2015;10:e0128361.
7. 4th Workshop of the European CMT-Consortium—62nd ENMC International Workshop. Rare forms of Charcot-Marie-tooth disease and related disorders. 16-18 October 1998, Soestduinen, The Netherlands. *Neuromuscul Disord*. 1999;9:279-287.
8. Daube JR. Rucksack paralysis. *JAMA*. 1969;208:2447-2452.
9. Wilbourn AJ. Ch 55: brachial plexus disorders. In: Dyck PJ, Thomas PK, Griffin JW, et al., eds. *Peripheral neuropathy*. Vol 2. 4th ed. Philadelphia, PA: Elsevier Saunders; 2005:1357-1358.
10. van Eijk JJ, Groothuis JT, van Alfen N. Neuralgic amyotrophy: an update on diagnosis, pathophysiology, and treatment. *Muscle Nerve*. 2016;53:337-350.
11. Nylund T, Mattila VM, Salmi T, Pihlajamäki HK, Mäkelä JP. Recovery of brachial plexus lesions resulting from heavy backpack use: a follow-up case series. *BMC Musculoskelet Disord*. 2011;12:62.

**How to cite this article:** Dorhout Mees SM, van Faals NL, van Alfen N. Backpack palsy and other brachial plexus neuropathies in the military population. *J Peripher Nerv Syst*. 2020;25:27–31. <https://doi.org/10.1111/jns.12363>